THE UNIVERSITY OF ALBERTA

TRANSITIVITY OF PREFERENCES

by

© OLA HINTON BRADBURY

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

DEPARTMENT OF PSYCHOLOGY

EDMONTON, ALBERTA

SPRING 1970

UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Transitivity of Preferences" submitted by Ola Hinton Bradbury in partial fulfillment of the degree of Master of Science.

Abstract

Transitivity has been considered basic to rational behavior; yet various demonstrations have been made of intransitive response patterns. In the research here reported, normal adult subjects gave preference responses for pairs of stimuli of four levels of verbal content. These were verbal statements of activity, named colors, unnamed colors and musical chords. Sets of stimuli were organized so as to provide all combinations of three, four, five, six and seven stimulus items taken two at a time. Sequences of pairs in sets were both ordered and randomly determined.

It was predicted that transitivity of preference would decrease with decreasing verbal content of stimuli forming sets. It was also predicted that an ordered presentation of stimulus sets would facilitate transitivity. All hypotheses were supported by results. Transitivity was found to depend upon amount of stimulus verbal content present, number of stimulus items composing sets and pattern of succession of pairs. Generalizations concern consistency models of choice and the concept of the "rational man".

Acknowledgements

T.M.N. and G.J.B., in their different ways, contributed much more to the success of this work than should have been asked of them.

Table of Contents

List of Tables

List of Figures

Introduction

The universe of classical and medieval cosmology was a universe of symmetry. Man, barring certain unfortunate aberrations, was seen as a diminutive embodiment of the same austere principles of consistency and harmony operating in the outside world. Particularly important for man were the demands of consistency for rationality and motivation. While physical science long since freed itself of the rational demands of the classical period, the system lingers in psychology in the concept of the rational man.

The research studies to be reported here reveal systematic inconsistency in preference responding. However, evidence of inconsistency exists at much more primitive levels of response. Ochs and Booker (1961) reveal asymmetry of spatial and temporal interaction of direct cortical response. Direct cortical response recordings were made at a mid-point between two bipolar implants in the visual cortex of a cat. The recorded form of response at the central point was found to be different for stimulation of electrode 1 followed by electrode 2 than for stimulation having the reverse order.

At a somewhat higher level of response and using human subjects, Garvill and Molander (1968) demonstrated that cross modal transfer operates asymmetrically. Testing for association of numbers to nonsense shapes, they found greater visual association following tactual experience with the stimuli than for the reverse order of experience.

On the other hand, evidence also exists of the other sort; formally consistent properties of human response can be shown. Corwin and Boynton (1968) demonstrated transitive properties of visual judgments of simultaneity. Objectively measured time must necessarily be transitive (e.g., if event A is simultaneous with B and B is simultaneous with C, A must be simultaneous with C). Subjective experience of simultaneity does not, however, follow objective time. Two flashes of light to two different retinal locations separated by as much as 30 msec. are experienced as simultaneous. This lack of correspondence between objective and subjective time opens the possibility that subjective time, represented by judgments of simultaneity of retinal light stimulation, may not be transitive.

Corwin and Boynton's study tests the hypothesis of a <u>simultaneity center</u> in the brain which is credited with being a convergence point for neural paths. Divergent retinal points are said to communicate stimulation to the <u>simultaneity center</u> at different rates.

If retinal points A, B, and C have respective transmission delays of 80, 50 and 60 msec., for stimulation of any two of the points to appear simultaneous to the observer, a certain delay should exist between the stimulations. If the visual judgment of simultaneity, evidencing the function of a hypothesized brain center, contains transitive properties, the third delay between stimulation of different retinal points which will produce the experience of simultaneity should be predictable from the first two. This was found to be the case, providing support for the

simultaneity center hypothesis. These results stand in support both of a transitive property of psychological response and of a neurological foundation of transitivity.

A well known non-commutative relation between stimuli is indicated in the psychophysical methods of average error and limits: Ascending and descending measures must be averaged to obtain a (true) difference threshold. Likewise, the presence of Weber fractions within certain ranges also indicates a non-reflexiveness of response. For example, in adding weight A to weight B, a difference may be detected, whereas going from B to A this might not occur.

In a summary statement on cognitive consistency theories, McGuire (1966) relates the current proliferation of consistency research to its more general suppositions about the nature of man. He says the consistency-complexity dispute has its prototype in the classical and romantic conceptions of man and maintains that the vogue in psychology wanders from one to the other of these poles.

Despite fairly abundant evidence suggesting non-commutativity at basic tissue levels and in sensory response, the notion of the rational man continues to suggest a great deal of cognitive research. Most of this, especially recently, has been in defense of classical rationality. Hammond (1964) stated the defense especially clearly in his paper, "Toward a recovery of rational man".

Problem

Rational organization of color

Color stimuli, especially in their relation to language, offer a utility to the investigation of rationality that has been diversely exploited. Color stimulation is ubiquitous and languages differ markedly in their treatment of the range of stimuli. For these reasons, Lenneberg and his associates (Brown and Lenneberg, 1954; Lenneberg and Roberts, 1956; Lenneberg, 1957 and 1961) have used colors in a number of tests of Whorf's basic hypotheses that language causes cognitive organization and that experiences are different for different linguistic communities.

The hue dimension of color depends upon a smooth rather than abrupt gradation of stimuli. Names, however, tend to be demarcative. In a sense, color names are categories. Important to cognitive structure is the number and range of categories a language provides its speakers for dealing with stimulus items. This categorization in relation to color stimuli is described by Lenneberg as the codability of color for language. For example, in English, yellow and orange are sharply separate categories in spite of the proximity of their locations on the stimulus continuum, whereas, in Zuni there is no differentiation of orange and yellow according to Lenneberg and Roberts (1956).

Considerable support for the dependence of cognitive structure on the codability of language is offered by Brown and

Lenneberg (1954). They found that colors with unequivocal names were more easily recognized than were colors not so easily named. This finding was later qualified by Lenneberg (1961) in a report that hue discrimination is affected by the subject's naming habits only for certain tasks, forcing the conclusion that codability is only one of several factors affecting color recognition. This does not detract from numerous cognitive implications of the language content of colors.

Langer and Rosenberg (1966) have further shown that the semantic associations of colors mediate cognitive functions. They demonstrated a greater difficulty in the naming of the ink color of a printed phonetic symbol when the symbol was printed in an incongruent color (e.g., blue for ZAH) than when it was printed in a congruent color (e.g.,red for ZAH).

The question of language content of colors has also been investigated in several ways by Chapanis (1965) in his work on color naming. Figure 1 depicts the hue distribution of the three dimensions of the color solid placing hue in context. For the question of name assignment to color stimuli, it is the hue aspect of color that is of primary interest.

Chapanis was concerned with the consensuality of assignment of hue names to specific color stimuli by English speaking subjects and the pattern of distribution of names around the hue circle. The equal divisions around the circle shown in Figure 1 represent equal numbers of discriminations using visual

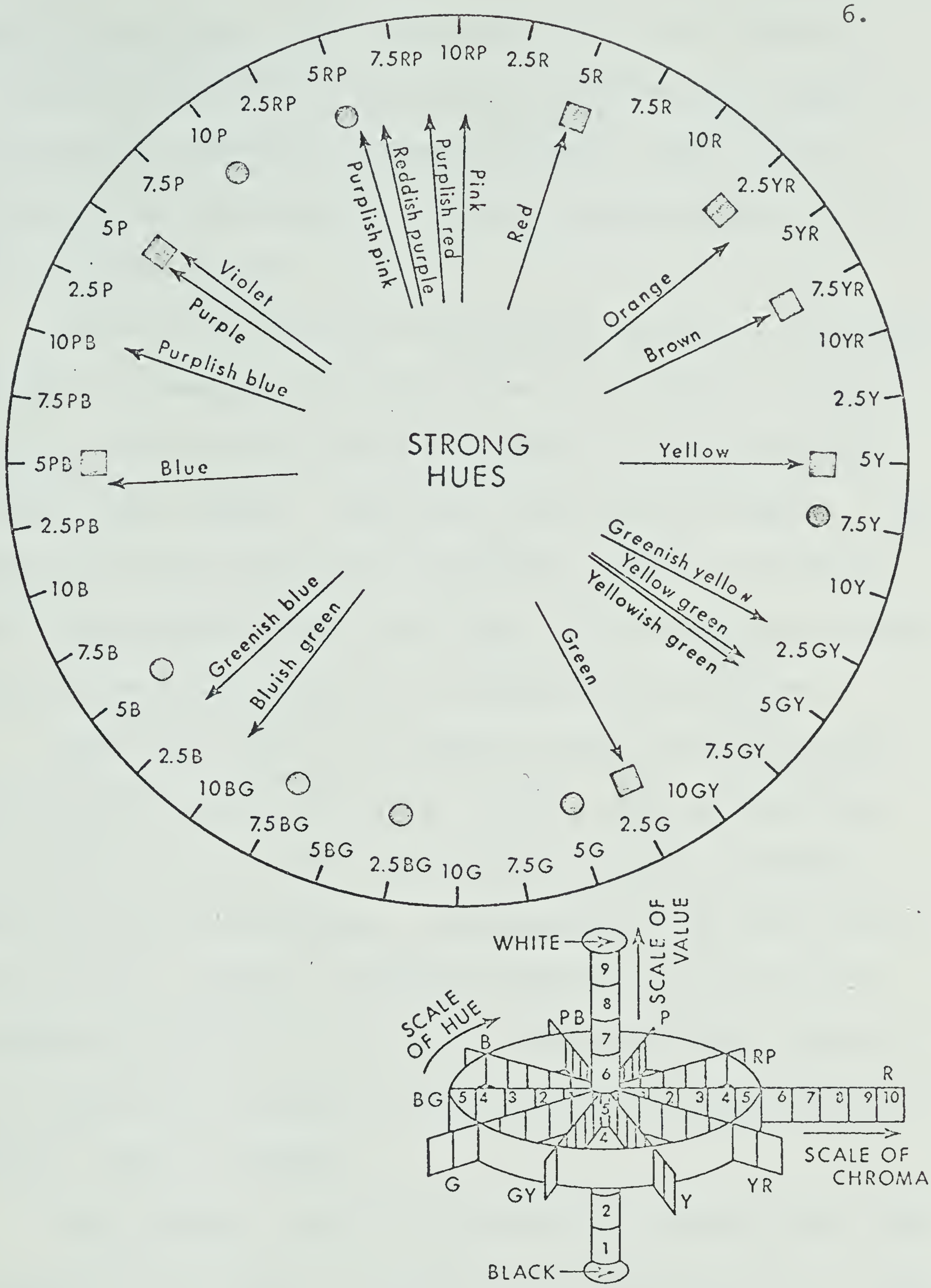

Figure 1: Average hue selections(arrows) by Chapanis's(1965) observers for English hue names qualified by the term strong. The scale and notations around the circle are Munsell hue designations. Squares and circles just inside various designations indicate the hue specifications of color stimuli selected as named (squares) and unnamed(circles). Below the circle appears a schematic representation of the three dimensions of the color space prepared by the Munsell Color Company.

matching techniques. The areas of the circle are, therefore, equally discriminable to the eye. It is obvious from Chapanis's findings for assignment of names to stimulus items that language operates differently in its discriminations than does the visual tissue system.

Certain areas of the hue circle shown in Figure 1 are heavily mapped into language; other areas seem to be virtually unsampled by our color names and can be interpreted as having relatively little verbal content. The arrows in the circle in Figure 1 indicate the average selections by Chapanis's observers for English hue names modified by the term <u>strong</u>. The term <u>strong</u> attached to color generally connotes high saturation and lightness.

Quite apart from their linguistic aspect, colors have certain advantages as psychological stimuli. They are available in enormous variety, they are relevant to people in numerous ways and they are versatile. The dimensions of the color stimulus have been carefully quantified permitting an exactness of stimulus specification and control. The specification system of the Munsell Color Company as represented in the <u>Munsell Book of Color</u> (1929) is standard.

Color stimuli, especially light, highly saturated hues, lend themselves very nicely to questions of preference while not carrying with them a complete logical sub-structure, as do such things as gambles between which subjects might be asked to choose or judgmental ratings of stimuli.

The issue of consistency

There are three commutative principles, symmetry, reflexivity and transitivity. It is the latter which has found most application in research on preference responding.

Transitivity is a relational law of formal consistency maintaining for all A, B, and C that $A > B$ and $B > C$ implies $A > C$. For preference, the simplest statement of this relation maintains that when item A is preferred to item B and B is preferred to C, A should be preferred to C. This is transitivity in its most straightforward form.

Psychologists have rarely studied logical transitivity. For purposes of psychological research the principle of stochastic transitivity has usually been employed. The stochastic concept takes into account the proportion of times one of a pair of compared items is preferred and states the relationship as a probability. In all of its three forms, stochastic transitivity maintains that if the probability of choosing A over B is greater than .50, and the probability of choosing B over C is greater than .50, then the probability of choosing A over C will be greater than some particular value.

The particular value is different for the several forms of the relationship known as weak, moderate, and strong. For weak stochastic transitivity, this minimal value is .50. For moderate stochastic transitivity, it is the smaller of the other two probabilities. For strong stochastic transitivity, it is the larger of the other two probabilities.

The simplest statement of transitivity (stated A > B, B > C, imply A > C) is rather uncompromising in its demands and was thus apparently limited in its applicability to choice, which is fairly often inconsistent. As Abelson (1964) observes, stochastic transitivity permits evaluation of the consistency of fairly inconsistent behavior by treating it relatively. Though it compromises the severity of the original notion of transitivity, it does permit the salvaging of transitivity's fundamentals for psychological purposes.

The invocation of the stochastic for a consistency principle, which in itself shows a certain element of contradiction, is part of the contention, rather wide in decision theory, that choice is cluttered with various randomizing influences (Thurstone, 1945; Coombs, 1958; Audley, 1966; Block and Marschak, 1960; Estes, 1961; Restle, 1961). While manifest inconsistency in choice behavior would seem to support an argument for the irrationality of man it is not used for this purpose. In different ways, all of these studies and theoretical applications of randomness to tranitivity strive to demonstrate that the irrationality is only apparent, that the inconsistency manifest in behavior is to be explained through some aspect of the person's relationship to the stimulus material, either in its structure or in the person's method of coping with it. Once these vagaries of the stimulus are made clear, the inconsistency of the final choice is supposedly explainable in rational terms. This then represents a defense of the rational man.

Coombs's (1958) treatment is representative and since it employs color stimuli, its methodology and results will be summarized. Coombs's primary interest was with the notion that psychological distance contributes to inconsistency of response in some singular way. Concerning himself with the laterality of distance of unidimensionally varying items, he tested specifically the contention that a different contribution to inconsistency will be made by bilateral and unilateral distance of gray stimuli from the observer's ideal gray when the stimuli are to be discriminated on the basis of closeness to the ideal. Given the hueless colors, very dark gray, dark gray, medium gray and light gray, if the observer's ideal gray is located between the dark and medium items, a comparison of items on opposite sides of the ideal will contribute differently to inconsistency than will a comparison of items on the same side of the ideal. In addition to this, any movement of the individual's location of ideal on the continuum will affect the hierarchy of items differently depending on their location on the same or on opposite sides of the ideal.

Coombs did not present stimuli to observers two at a time. Instead he presented all combinations of 12 gray chips taken four at a time. By this method, each pair of stimuli appeared a number of times embedded in one of the many combinations of four, permitting the inference of paired comparisons from the ranking of each set of four as well as the assessment of the percentage of times one of a pair was chosen over the other. Here lies the significance of the study for stochastic transitivity.

The bilateral spread of some of the sets of compared stimuli contributed to quite a few violations of strong stochastic transitivity.

Violations of weak stochastic transitivity have proved more elusive. It is only very recently (Tversky, 1969) that very wide experimental demonstration of the failure of weak stochastic transitivity in choice responses has been made. Tversky constructed situations in which alternatives differ on two relevant dimensions, such as probability of win and amount of payoff in gambles. These are made to vary in such a way that the values on the two dimensions are negatively correlated and the differences between adjacent items on the first and most consequential dimension are negligible. Using such models, Tversky has been able to dispose the individual to a rational strategy leading to an illogical conclusion.

The following illustration from Tversky's report (1969) is widely applicable and has been suggested (May, 1954) in relation to economic theory.

		Dimensions	
		I	II
Alternatives	a	2	6
	b	3	4
	c	4	2

A person asked to decide between paired presentations of a, b, and c is told that Dimension I is of primary consideration and that Dimension II is to be referred to only when no decision can be reached otherwise. The subject can decide that

one point difference in Dimension I is insufficient to distinguish alternatives and thus resort to the values of Dimension II. Thus when choosing between alternatives a and b, recourse would be made to Dimension II, which heavily favors choice a. When choosing between b and c, the same strategy decides in favor of b. But when a is compared to c the difference on Dimension I is substantial and decides the comparison in c's favor. Through this procedure the subject arrives at the apparently reasonable result, $a \succ b$, $b \succ c$, $c \succ a$ ($\succ$ represents "is preferred to"), which is intransitive. It is the deviously palatable rationality of the initial strategy that makes the final fall into error possible much in the tradition of the baited hook, which is possibly the explanation for the incredulity of Tversky's subjects when confronted with the intransitivity of their own behavior.

Tversky applied this form to gambling choices, inversely varying probability of winning and amount of payoff; and was able to produce consistent violations of *weak stochastic transitivity*. Similar results were obtained for evaluations of hypothetical applicants to university admission.

It might be mentioned finally that about fifty years ago M.F. Washburn (1921) conducted research revealing a disparity between judgments of the pleasantness of color combinations and of the colors seen singly. Before that work, it was widely assumed that the pleasantness of a color combination held an additive relation to the pleasantness of each of the combination's individual

members. However, Washburn's finding is of more significance to the question of rationality than to color vision.

The position she opposed in her study was a product of a wide assumption of rational man, an assumption born out of the mentalistic analogy to chemistry. To this nineteenth century rationalism, man was still the microcosm of the ordered world of classical and medieval cosmology. For psychology the metaphor had taken on the additional burden of specific chemical notions.

The pleasantness of a color combination was assumed to be additively related to the pleasantness of its components because it followed logically from a formal analogue that it should , and not because such a relationship characterized behavior. The rational man, it was held, should behave logically. And, the primary result of Washburn's study was a demonstration of a formally inconsistent element in behavior. This early theoretical position of Washburn's seems to stand in rather sharp contrast to more recent speculation.

Also, generally studies of transitivity of preferences have not dealt with preference in the sense of subjective "Pleasantness " of Washburn's (1921) study. Instead the preference response is generally entangled with some task which itself carries certain logical implications. For example the preference response of Coombs's (1958) experiment is not the preference of "Which do you like best " but a critical decision to be reported as to where on a clear polarized continuum a number of items are placed. The principle of the polarity, the stated task of rank

ordering and the similarly stated matter of distance present the subject with fragments of a ready made rationality. The same is true of the gambling alternatives of Tversky's (1969) study and others (Griswold & Luce, 1962). The very problem of a gamble presents the subject with the logical system of probability.

This study abandons the notion of randomness of choice behavior by ignoring the various stochastic forms of transitivity, by presenting full sets of paired combinations and taking measures of the relative transitivity manifest in responses to the set. There is no concern with repeated presentation of a pair to a subject to determine the likelihood of his choosing one or the other item over a number of choices. Rather, the concern is for the single encounter with the pair, the form of the pair's presentation and the implications the response to this single presentation in context has for the set of responses.

Tversky's (1969) design ingeniously arranges the external stimulus organization in an artificial way, though in such a way as to make transitive behavior unlikely. But even so, he worked only with subjects screened on the basis of their tendency to demonstrate intransitive behavior. Intransitivity should not be so difficult to produce.

In the present study, we follow Washburn's attempt to divest the demand on the subject of any extraneous <u>task</u> meaning. There is no external criteria for evaluation of a pair. The subject

chooses which item pleases him most. This is an attempt to make the consistency or inconsistency of response internal rather than external in its inception.

Hypotheses

The present research proceeds from a skepticism, such as that of Washburn, that man is rational in some dispositional or motivational sense. Departures from logically derived expectations are not taken to represent aberrent or unnatural states of affairs. Instead an attempt is made to reveal rationality as an invention, a structure imposed on man, who is inherently without cognitive organization of a rational sort.

If this position is correct, we should expect to see the benefits (or detriments) of the rationality slowly developed in the individual; we should expect to find it carried, perhaps ungracefully at times, in his other inventions, the most conspicuous of which is language; and we should expect behavior reflecting this invention of rationality to fall under control of manipulations of the agents holding the structure.

If it is, in part, the language man uses and not the man himself, independently, that harbors formal logical relationships, we might expect to find that manifestations of logic in response varies in some predictable way with the amount of verbal content available to the individual in the stimulus situation. Verbal content should, so to speak, be a fabric on which rational behavior clings rather than the person being a source of rational

emission which is merely provided an imperfect expression by language.

Two general hypotheses are tested. It is hypothesized that the rationality of behavior represented by internal consistency of preferences should decrease as the verbal content of the stimulus material decreases. It is further hypothesized that, within this situation of varying verbal content, rationality should decrease as there is an increase in the complexity of the stimulus situation (represented by increased numbers of stimuli to be dealt with) and that rationality should be enhanced when an ordered, predictable sequence pattern governs the appearance of stimulus items.

Method

Apparatus

Four classes of stimuli were employed. These were: A. Verbal statements of activities; B. Well named colors; C. Poorly named colors; D. Musical chords.

The main body of research dealt with color preferences and the implications imposed on rationality or consistency of response by the ease of difficulty of naming a particular color stimulus. Chapanis (1965) reports research on color-naming using Munsell chips in which the subject was given a common color name and asked to choose the one color chip which best fitted the name. Figure 1 shows the positioning on the hue circle of average name selections by Chapanis's observers as well as a

schematic representation of the three psychological dimensions of the color space in Munsell terms.

Taking only the hue dimension of the color solid, it is obvious from Chapanis's results that certain areas of the circle are much better represented with English color names than are other areas in spite of the fact that items from the various areas are equally discriminable employing matching techniques. Surfaces which a preponderance of English speaking observers selected to represent common English hue names were regarded as well named in Chapanis's work. The upper portion of Table 1 provides the Munsell characteristics of surfaces used as well named color stimuli in the current study and gives the English names, according to Chapanis, these colors attempt to represent. These were derived, with a single exception, by taking the seven hue positions, represented by the names red, orange, brown, yellow, green, blue and purple, at maximum chroma and maximizing value for each of these hue-chroma combinations. The latter procedure was an attempt to eliminate the two dimensions chroma and value as sources of variance.

The single exception to the principle of maximizing chroma and value occurs with brown, Munsell 7.5 YR. Since brown is a desaturated, dark member of the orange-yellow hue area, different chroma and value specifications apply to it.

The policy of maximizing chroma appears to do some violence to Chapanis's recommendations in the case of the red or Munsell 5.0 R item. When chroma and value is maximized together for this

item the selection becomes 5.0 R 5/14. However, it is clear from Chapanis's results that it is this item's close neighbor, 5.0 R 4/14, on which there is best agreement for assigning the name, strong red.

As Figure 1 shows, there is a considerable area of the circle between 5.0 PB and 2.5 B and between 10 BG and 2.5 G in which there is no dependable assignment of hue names in English. In general, the entire area between blue and green contains wave length distributions that are not well specified in English even though, when a matching technique is used, these same distributions are as discriminable as those that are well named. Instead of names being distributed evenly around the hue circle as are matched discriminations, there are blank spaces as well as clusters of names.

The spacing of the well named hues red, orange, brown, yellow and green, as shown in Figure 1, was rotated on the circle so as to provide comparably distanced hue locations in poorly named areas. A similar rotation, though not so precise in its spacing, was performed with the well named hue locations of blue and purple to provide two final poorly named placements on the circle. Squares and circles along the perimeter of Figure 1 show locations, within a three dimensional color space, of both named and unnamed hues for this study. Following the procedure already used in the selection of well named colors, the seven surface colors listed in the lower portion of Table 1 were specified.

Table 1

Experimental code and Munsell specifications for <u>named</u> and <u>unnamed</u> color stimuli used in transitivity of response research with normal adult subjects. All color stimuli were in the form of 6" X 10" Munsell papers in glossy finish.

<u>Named Colors</u>

Experimental Code	Munsell Specification	Hue Name
A	2.5 YR 6/16	orange
B	5.0 Y 8/14	yellow
C	2.5 G 5/12	green
D	7.5 YR 3/2	brown
E	5.0 R 5/14	red
F	5.0 PB 5/12	blue
G	5.0 P MAX (3.8/11)	purple

<u>Unnamed Colors</u>

Experimental Code	Munsell Specification
A	7.5 BG 5/8
B	5.0 G 6/10
C	7.5 Y 7/12
D	2.5 BG 5/10
E	5.0 B MAX (5.3/8.8)
F	5.0 RP 5/12
G	10 P 5/12

Both sets of color stimuli, initially in the form of 6" X 10" papers, were mounted on 6" X 10" cardboard pieces so as to facilitate their being handled and repeatedly placed on the presentation stand built for the experiment. This stand, constructed of plywood and measuring 54" on its side X 36" high, revealed to the subject at eye level a single opening slightly less than 6" X 10" in size On the reverse side of this stand a sliding piece of plywood with two openings at its extreme ends to match the aperture to the front permitted the mounting and successive presentation of pairs of color sheets and, with its blank middle area, provided for the opening facing the subject to be blank when no color was being presented.

This viewing screen was painted the flat gray recommended by the Munsell Color Company for presentation of bright colors. For both experimental color presentation and for testing of color vision the light source was a Macbeth Daylighting Corporation Examolite Model TC 440.

Seven statements from the Kuder Personal Preference Inventory were taken, with minor revision, to serve as verbal statement stimuli. These were: Stimulus A. Take apart a new mechanical toy; Stimulus B. Write a political campaign song; Stimulus C. Make all arrangements for a big wedding; Stimulus D. Make a study of propaganda methods; Stimulus E. Assemble a good assortment of tools; Stimulus F. Visit an advertising agency; Stimulus G. Tinker with a broken sewing machine. These items

were selected on the basis of their representing a wide variety of activities, demanding a length of time that is more than a few minutes and less than a major involvement, and their taking roughly the same length of time to read. For purposes of presentation, the statements were photographed and placed on slides and shown with a Carrousel slide projector.

Musical chords were selected to satisfy the need for a stimulus with little verbal meaning. Using a tape recorder, seven chords were recorded as played on an electric organ. These were: Stimulus A. B minor 4-note chord; Stimulus B. E major 4-note chord; Stimulus C. Dominant 7th on C; Stimulus D. Diminished 7 th on F#; Stimulus E. 3rd inversion of the dominant 7th on G; Stimulus F. E major triad; Stimulus G. E minor 4-note chord.

Subjects and Procedure

All responses were preferences between pairs of items. The objects in all aspects of the study was to present successively all members of a set of stimulus items in all possible paired combinations, thus forming a full set of comparisons. Responses to a full set of comparisons permit the assessment of the degree to which the subject was consistent (transitive) in his choices. Consistency measures were taken both for ordered sets, i.e., when there was an obvious order in the succession of stimulus pairs; and for mixed sets, i.e., when this order was obscured by employing a randomly decided succession of pairs.

For any three stimulus items in either ordered or mixed sets,

three pairs are required to exhaust all possible combinations. Four stimuli require six pairs; five require ten pairs; six require fifteen pairs and seven require twenty-one pairs. This experiment dealt with the complete pairing of all of these numbers of stimulus items.

Ordered sets: The following sequence of pairs was chosen to satisfy the ordered sets condition:

1	AB	8	BE	15	EF
2	AC	9	CE	16	AG
3	BC	10	DE	17	BG
4	AD	11	AF	18	CG
5	BD	12	BF	19	DG
6	CD	13	CF	20	EG
7	AE	14	DF	21	FG

This twenty-one pairs represents, for this experiment, the full ordered set of any seven stimuli. It fulfills the definition of an ordered set since there is an obvious and consistent pattern in the succession of paired items. Notice, in this case, that the latest member of any group of pairings (e.g., D being paired with A, B, and C) is always put second and each previous member is paired with it in successive turns (e.g., AD then BD then CD). This subtlety of structure will be of importance in later discussion.

This particular order of pairings was chosen over others with comparable amounts of pattern because a full set of any given number of stimulus items is completed before the next item is added. Ordering in this way allows for a successive addition of stimulus items so as to form an indefinitely expanding set. Responses for such an ordered set of four stimuli are merely the responses for the set of three stimuli plus the responses for each of those three

items combined with the fourth. A single subject will, therefore, provide data for sets of three, four, five, six and seven stimuli merely by responding to the full set of twenty-one pairs. The ordered set arrangement was expected to facilitate the subject's rational treatment of the choices because it presents the same pattern repetitively.

Mixed sets: The purpose of the mixed sets arrangements was to eliminate whatever aids the organized pattern of the ordered sets offers to consistency of response, while still testing for response transitivity in a full set of stimuli. To this end, a random order of the total pairs for any number of stimuli were selected. Since this procedure does not permit the retrieval of responses to a smaller set from those of a larger one in any simple way (as did the ordered sets arrangement), as many different sets were required as there were levels of complexity. Table 2 shows the randomly selected successions of pairs chosen to constitute the mixed set for each number of stimulus items. Notice that the response to any number of stimuli larger than the first level is contaminated by the interposition of pairs not in the set. For example in the set of four stimuli the subset BC, AB, AC is separated by AD, CD and BD.

Since the experiment lends itself to either group or individual administration, and since the designs require large Ns, subjects were run in whatever numbers they could be induced to appear with the restriction that no group contained more than 15 subjects. Most frequently groups consisted of 6 - 8 people, rarely was the number over 10, and never was a subject run alone.

Table 2

Randomly determined sequence of pairs forming all combinations of two for three, four, five, six and seven stimuli used as mixed sets in transitivity of preferences experiment with normal adult subjects.

Set of Three Stimuli		Set of Six Stimuli		Set of Seven Stimuli	
1	AC	1	CD	1	EF
2	BC	2	DE	2	AC
3	AB	3	BF	3	AF
Set of Four Stimuli		4	CF	4	CF
		5	BE	5	FG
1	BC	6	EF	6	AD
2	AD	7	DF	7	CG
3	AB	8	AE	8	AE
4	CD	9	CE	9	DG
5	BD	10	AD	10	DF
6	AC	11	BD	11	CD
Set of Five Stimuli		12	BC	12	EG
		13	AC	13	BC
1	CE	14	AB	14	BG
2	AD	15	AF	15	AB
3	DE			16	BE
4	AC			17	AG
5	CD			18	CE
6	AE			19	BD
7	BD			20	BF
8	AB			21	DE
9	BC				
10	BE				

The procedure for dealing with subjects was the same for ordered and mixed sets groups. In all cases subjects were asked to sit in desk chairs provided. When color stimuli were shown, subjects were seated so as to be able to see clearly the viewing window in the presentation stand.

After subjects were seated, response sheets bearing thirty numbered pairs of circles were passed out and subjects wrote their names in a designated space. Instructions were then read. Subjects shown named and unnamed color stimuli were read:

> This experiment deals with preferences. I am going to show you some colors through the window on this stand. The colors will always be presented in pairs, first one then the next will be shown; and out of each pair I want you to choose the one you prefer, or the one that pleases you most, and I want you to indicate your choice on the response sheets I have passed out to you. On these sheets you see pairs of circles numbered from one to thirty. If in the case of the first pair you prefer the first color over the second, place some sort of mark in the first circle of pair number one. If you prefer the second color, make a mark in the second circle of the first pair of circles, and follow this procedure for all the following pairs of colors you are shown. Even though the sheets contain thirty pairs of circles, you may not necessarily be shown that many pairs of colors.
>
> I will ask you to make a choice out of each pair even if you do not see too much difference between the items. And do not return and change an answer once we have gone on and seen more pairs.
>
> The colors you will be shown will be colors of surfaces, however, I want you to think of a color you see as the color in general rather than the color of some specific thing. I say this so that you

> will not think, for example, of one color you see as the color of a shirt or blouse and the next color as the color of a car or house. I want you to think of all the colors in the same general context.

After any questions were dealt with, the subjects were told: "I shall now demonstrate with a pair of colors. Do not indicate a choice for this pair as it is only a demonstration." That demonstration being made, the subjects were finally told: "As you just saw, the colors will be present for about five seconds and there will be about a ten second interval between pairs. I shall announce the number of the pair that is about to appear each time. Are there any further questions?"

As soon as any questions raised by the instructions were settled, the stimuli were presented as described in the instructions: five seconds exposure of the stimulus; ten second interval between pairs; and announcement of the number of the pair preceding its presentation.

Immediately after making the last response, subjects turned their papers over. On the reverse side were spaces numbered one to fourteen. They were told that they would be shown, rather quickly, a succession of colors and that for each they were to write, in the appropriate space, the name they would use for the color. They were further told that they could use any name they thought most appropriate to the color at hand. Subjects were told to request a slower pace if the presentation was too rapid for comfortable naming of the colors.

Instructions to those subjects shown <u>verbal statement</u>

stimuli were:

> This experiment deals with preferences. I am going to show you some statements on this screen. They will be statements of activity, statements of things to do with your time. I want you to imagine that you have some free time.
>
> The statements will always be presented in pairs; first one, then the next will be shown. Out of each pair, I want you to choose the one you prefer; that is, the one activity you would prefer to spend your free time doing if you had a choice only of those two. And I want you to indicate you choice on the response sheets I have passed out to you.

These instructions then generally followed those for colors.

Subjects presented tone stimuli, were asked, after presentation of a demonstration pair, if volume was adequate and if the tones could be heard clearly. Also, the request was made that when a tone was sounding the head be kept stationary since moving the head at such times might change the quality of the sound.

After all responses were made, the response sheets were collected and if no further conditions were to be run on these subjects, they were encouraged to ask questions about the study and to make any comments they might care to make.

All subjects were dismissed at this point excepting groups who had received color stimuli. These were detained long enough for individual color blindness testing using the American Optical Company H-R-R Pseudoisochromatic Plates. Color stimuli subjects were also questioned as to their fluency in a foreign language.

Six hundred and twenty-four undergraduate university students participated in one or more of the five parts of the experiment described.

By excluding those with known color defects and multilingual persons, our sample matched that used by Chapanis (1965) when he gathered data on the color naming of surfaces.

Subjects were sometimes used in more than one condition. The procedure for assignment of subjects was as follows. It was a requirement for both _ordered_ and _mixed sets_ conditions that groups be composed of no fewer than 20 subjects. In the case of _ordered sets_, subjects were run for each of the four stimulus types until each group contained at least 20. Namely, 22 subjects were run for _verbal statement stimuli_; 22 subjects for _named colors_; 20 for _unnamed colors_; 23 for _tones_.

The _mixed sets_ condition involved a separate group of subjects for each of the 20 cells of the 4 X 5 design comprised of four stimulus types and five levels of set complexity. The equal number for each group was determined by accepting at least 20 subjects for each condition and then randomly eliminating any in excess of 20.

A total of 150 subjects contributed color naming responses. Other than the 43 making up the two _ordered sets_ color groups 107 subjects had taken part in a similar paired comparison color preference study prior to responding.

Miscellaneous procedures: In extended responding per-

formance decrements sometimes occur. To discount the possibility that extended responding might account for the expected lower scores in sets of greater complexity (i.e., greater length), one ordered set of five statements (A,B, C, D, E) was presented to 19 subjects immediately on the heels of another ordered set of four statements none of which was A, B, C, D or E. The analysis considered whether the group score on this set of five statements would be lower than the experimental ordered set score for five statements. These subjects were treated exactly like the other ordered sets statements group.

Comparison was made of differently structured ordered and mixed sets. The mixed sets arrangement has structure; one cannot avoid structure in any such set, even though it is different from the tight predictable form of the ordered sets. It was decided to compare, using sets of three statements, the different results achieved with the ordered set already in use (i.e., AB, AC, BC) and with a mixed set, BC AC, AB. For purposes of structural comparison the ordered

	AB		BC
set is,	AC	and the mixed set is,	AC
	BC		AB

In the case of the ordered set, the same stimulus (e.g., A) appears initially in the first two pairs, and a different stimulus (e.g. C) appears finally in the last two pairs. The mixed set reverses this structure. Its first two pairs

are concluded with the same stimulus (e.g. C), and its last two pairs begin with the same stimulus (e.g., A). One important difference between these sets is that the <u>ordered</u> structure stresses an anterior beginning followed by a consequent conclusion, whereas the <u>mixed set</u> stresses a consequent beginning followed by an anterior conclusion. In an auxiliary experiment one group of 30 subjects was presented the <u>ordered set</u> of three statements and another group of 30 subjects was presented the <u>mixed set</u>. Ten of this total (five in each group) were without previous experience in the experiment. The others had just taken part in one of the other <u>mixed sets</u> conditions.

Results

Each full set of responses was scored on the basis of the coefficient of consistence (Kendall and Smith, 1940; Kendall, 1962; Harary, Norman and Cartwright, 1965). The technique recognizes that any given complete set of comparisons inherently contains the opportunity both to respond with complete consistency and to give a maximum number of inconsistencies. The coefficient of consistence for a full set of comparisons is arrived at by deriving the fraction of obtained inconsistencies over the maximum number of inconsistencies possible and subtracting this fraction from the number one. Values of this measure thus range between zero, the score for maximum inconsitency, and 1.0, indicating a completely transitive response set.

The distributions of scores resulting were found to be rather heavily skewed in a negative direction. Thus, inverse sine transformations were applied. These transformed coefficients are the consistency scores dealt with throughout this report.

Ordered sets

One of the two primary hypotheses this research attempted to support was that consistency of preference response, represented as transitivity, would vary with differing amounts of verbal content in the material to which the subjects responded. This contention is supported in Table 3 by the significance of

Table 3

Summary of analysis of variance for effects of stimulus type and level of complexity of <u>ordered sets</u> of stimulus items. Measures are consistency scores of paired comparison preference responses by normal adult subjects.

Source	d.f.	M.S.	F.	P
A	3	.565	3.63	<.05*
Error (A)	84	.156		
B	4	.199	11.40	<.01**
A x B Interaction	12	.033	1.89	<.05*
Residual	336	.017		

A = stimulus type

B = level of set complexity

the A main effects ($P < .05$) of the repeated measures analysis of variance using an unweighted means solution.

Of further primary interest was the hypothesis that consistency would vary with varying levels of complexity in the sets of stimuli (i.e., as there were varying numbers of stimuli comprising sets.) This expectation is also supported by Table 3 as the B main effects ($P < .01$).

Figure 2 presents the ordered sets data in graphic form. The differences between groups just mentioned are shown in this graph. Generally the ordinal relationship of higher to lower scoring groups at each level of set complexity is first statements, then named colors, then unnamed colors, then tones. The differences do not seem, however, to space groups evenly along the full range of the difference. Named colors produce results more like those of statements than like those of unnamed colors. Notice also how scores tend to decrease as number of stimuli in sets increases.

Although no predictions were made concerning interactions, Table 3 shows that the two main variables did interact significantly ($P < .05$). Apparently, changes in the level of complexity of stimulus sets does not affect scores of the various stimulus types in the same way for ordered sets.

Table 4 presents frequency distributions for all ordered sets conditions. The column of scores lists all scores possible for each set. These show that for all but a few of the most complex sets (i.e. sets of six and seven unnamed colors and tones),

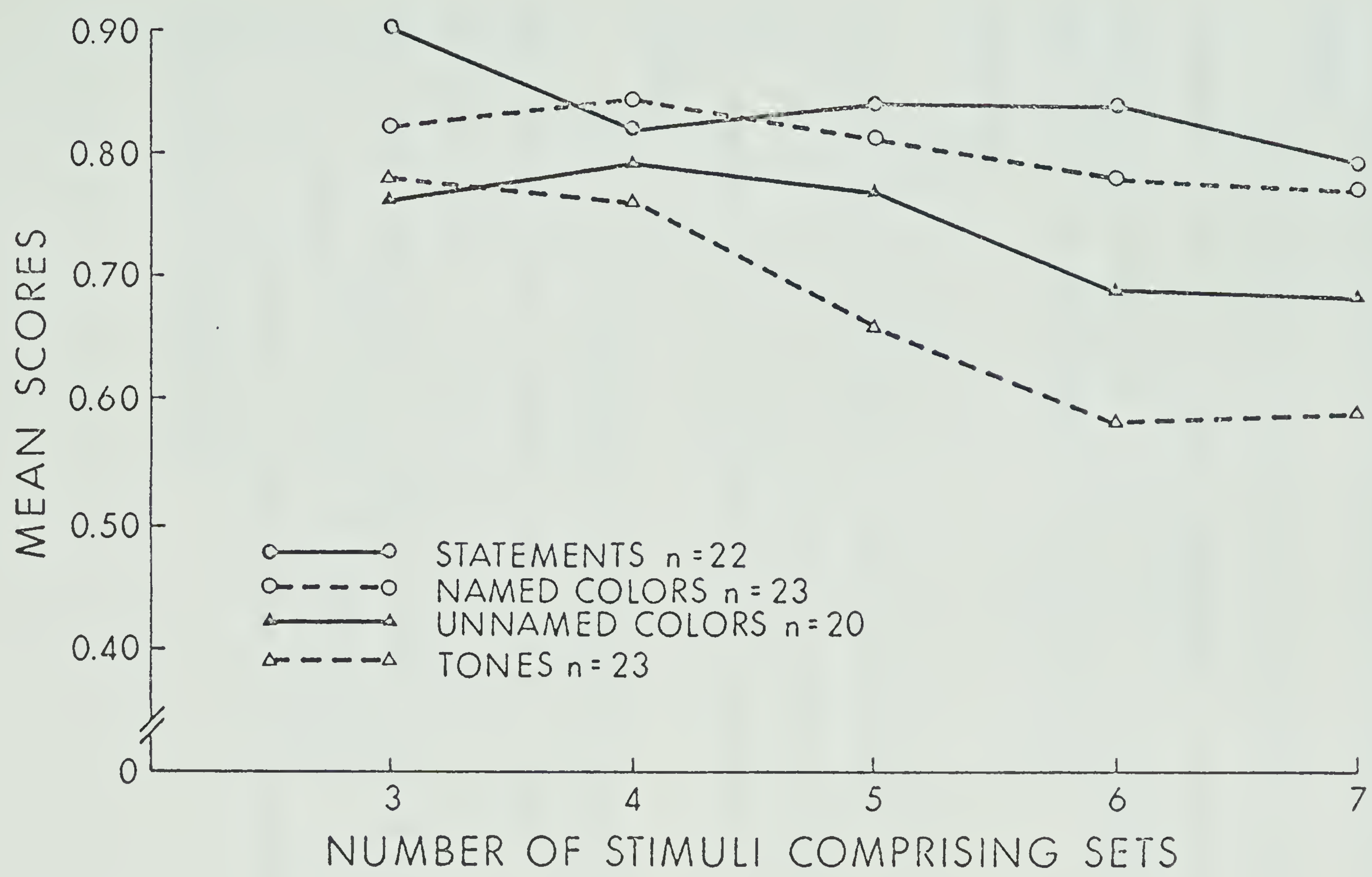

Figure 2: Mean consistency scores of paired comparision preference responses by normal adult subjects for ordered sets of four stimulus types plotted against level of set complexity.

most subjects achieve complete transitivity. However, these subjects vary widely in this respect. Tversky (1969) also reports that only a fraction of subjects are inconsistent. It is individuals from this small population that make up his subject sample.

Also of special interest is the unexcepted transitivity of responses in the set of three statements. No other condition of any type yielded such a group score. We shall see, however, this result was not supported by a later test.

Mixed sets

The data for mixed sets were also analyzed by an analysis of variance design with results summarized in Table 5. As in the case of ordered sets, the hypothesized difference between scores for stimulus types is supported by the significance of the A main effects (P <.05).

Also, the B main effects difference (P <.01) supports again the prediction that different levels of set complexity will yield different scores. These A and B main effects results for mixed sets show themselves at roughly the same level of confidence as do the corresponding results for ordered sets. In this case, however, the interaction of stimulus type and set complexity was not significantly demonstrated.

Table 4

Distribution of consistency scores of paired comparison preference responses by normal adult subjects for ordered sets of stimuli of four levels of verbal content with sets at five levels of complexity.

	Stimulus Type			
Consistency Scores	Statements	Named Colors	Unnamed Colors	Tones
	Sets Composed of Three Stimuli			
.90	22	21	17	20
.00	0	2	3	3
	Sets Composed of Four Stimuli			
.90	18	21	16	19
.45	4	1	3	1
.00	0	1	1	3
	Sets Composed of Five Stimuli			
.90	18	17	13	10
.63	2	4	3	4
.51	2	1	2	5
.39	0	1	2	1
.27	0	0	0	3
.00	0	0	0	0

Stymulus type

Consistency Scores	Statements	Named Colors	Unnamed Colors	Tones
	Set Composed of Six Stimuli			
.90	17	13	9	6
.70	3	6	2	2
.60	1	1	3	3
.53	0	2	2	3
.45	1	0	1	3
.38	0	0	1	2
.30	0	1	2	3
.21	0	0	0	1
.00	0	0	0	0
	Set Composed of Seven Stimuli			
.90	12	11	7	4
.75	4	5	2	2
.68	2	3	1	4
.63	2	1	2	1
.57	1	0	3	1
.53	0	1	1	2
.49	1	1	2	1
.45	0	0	0	2
.41	0	1	1	3
.37	0	0	0	2
.33	0	0	1	0
.27	0	0	0	0
.22	0	0	0	0
.15	0	0	0	1
.00	0	0	0	0
	n=22*	n=23	n=20	n=23

*With measures repeated at each level of set composition for each stimulus.

Table 5

Summary of analysis of variance for effects of stimulus type and level of complexity of <u>mixed sets</u> of stimulus items. Measures are consistency scores of paired comparison preference responses by normal adult subjects.

Source	d.f.	M.S.	F	P
A	3	.1771	3.20	<.05 *
B	4	.3554	6.42	<.01 **
A x B Interaction	12	.0385	0.695	n.s.
Error	380	.0554		

A = stimulus type

B = level of set complexity

Figure 3 presents these mixed sets data graphically. Here the hypothesized results show themselves fairly well from level five through seven of set complexity. With the exception of the indistinguishable difference between both color groups and the tone group at the fifth level, the groups are well divided in the expected direction. The group of six tones is peculiarly out of line, although this is the the desired direction. Stimulus groups are evenly spaced at the seventh level. As with the ordered sets data, the mixed sets scores for the more complex sets tend to be lower.

Figure 3 also shows that ordinal relations between points is discrepent at lower levels of set complexity. This will be discussed later.

Table 6 presents the frequency distributions for all mixed sets conditions. In these sets, no group achieved complete transitivity, although, as with the ordered sets, generally less than half of the subjects in any group depart from transitivity. In these cases, the point at which at least half of the subjects make at least one intransitive response arrives somewhat earlier than with ordered sets. Here the group for five tones responds in this way, followed by groups for six named colors, unnamed colors and tones as well as seven named colors, unnamed colors, and tones. None of the statements groups shows a proportion of response intransitivity greater than one-half. The worst showing in this regard is made by the group for six tones, only one member

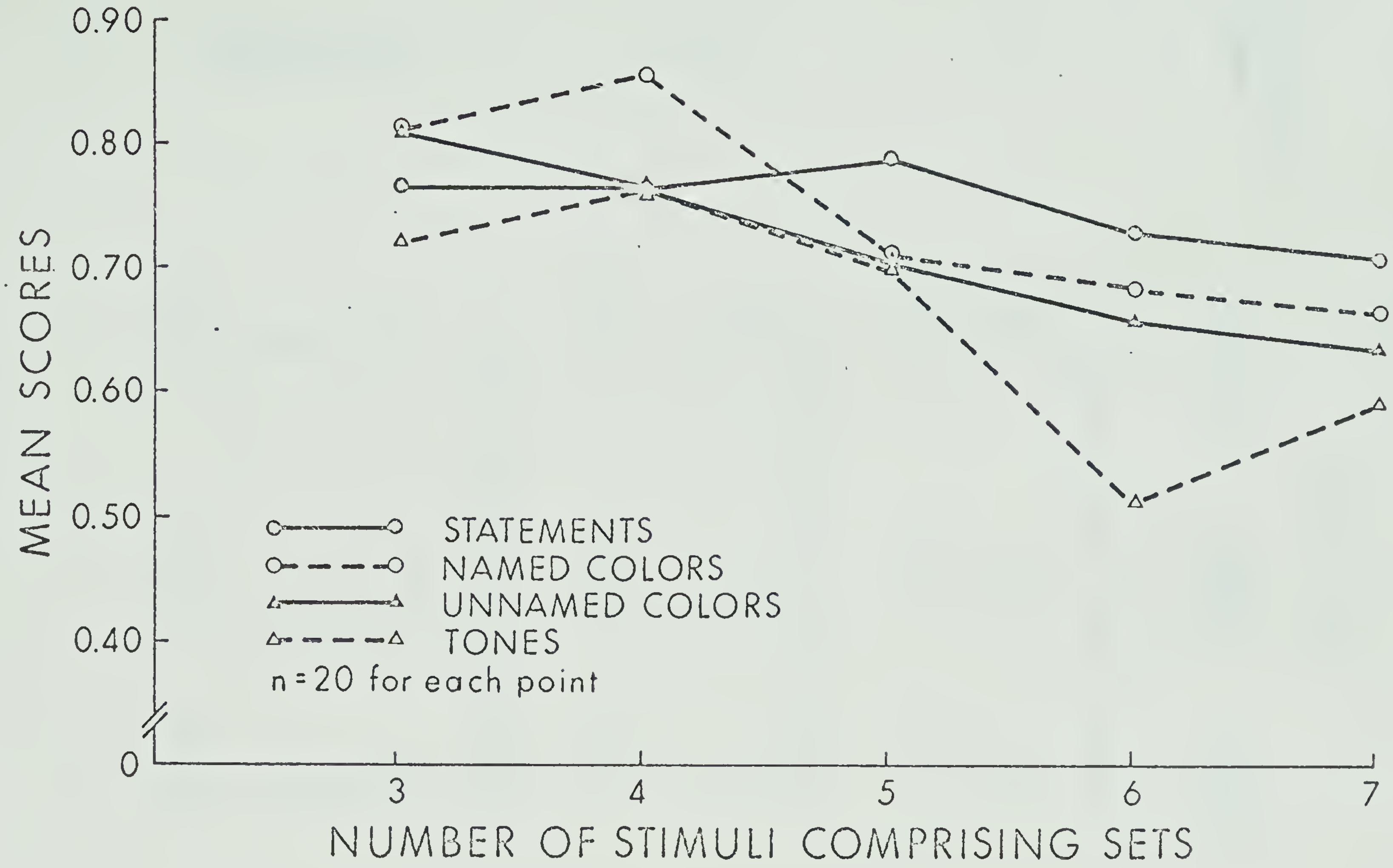

Figure 3: Mean consistency scores of paired comparison preference responses by normal adult subjects for mixed sets of four stimulus types plotted against level of set complexity.

Table 6

Distribution of consistency scores of paired comparison preference responses by normal adult subjects for mixed sets of stimuli of four levels of verbal content with sets at five levels of complexity.

Consistency Scores	Statements	Named Colors	Unnamed Colors	Tones
	Sets Composed of Three Stimuli			
.90	17	18	18	16
.00	3	2	2	4
	n= 20	n= 20	n= 20	n= 20
	Sets Composed of Four Stimuli			
.90	16	18	15	16
.45	2	2	4	2
.00	2	0	1	2
	n= 20	n= 20	n= 20	n= 20
	Sets Composed of Five Stimuli			
.90	14	10	10	9
.63	3	5	2	7
.51	1	3	6	2
.39	2	0	2	0
.27	0	2	0	2
.00	0	0	0	0
	n= 20	n= 20	n= 20	n= 20

Stimulus Type

Consistency Scores	Statements	Named Colors	Unnamed Colors	Tones
Sets Composed of Six Stimuli				
.90	11	5	7	1
.70	3	5	4	2
.60	1	7	3	5
.53	0	2	1	5
.45	2	1	3	3
.38	2	0	0	1
.30	1	0	0	2
.21	0	0	2	0
.00	0	0	0	1
	n= 20	n= 20	n= 20	n= 20
Sets Composed of Seven Stimuli				
.90	10	4	3	3
.75	2	2	2	0
.68	0	5	4	4
.63	0	1	3	2
.57	3	3	2	3
.53	0	3	3	0
.49	2	1	0	1
.45	1	0	0	4
.41	0	1	3	2
.37	1	0	0	1
.33	0	0	0	0
.27	0	0	0	0
.22	0	0	0	0
.15	1	0	0	0
.00	0	0	0	0
	n= 20	n= 20	n= 20	n= 20

of which demonstrated complete transitivity of response.

Also in the six tones group, one person's responses received a score of zero, demonstrating utter inconsistency, a remarkable achievement considering that the subject supplied all eight possible cyclic triples (i.e., intransitive relations of three items) in 15 responses. Even this is not the most noteworthy of such results. The low performing subject in the group receiving seven statements scored .15, demonstrating all but one of 14 possible cyclic triples in 21 responses. There are grounds for discarding such person's responses as indicative of the so-called 'diabolical subject' (Harary, Norman and Cartwright, 1965). However, lacking any outward manifestation of ill will, impairment or incompetence data was accepted at face value. Tables 4 and 6 indicate there are very few such subjects.

Comparison of ordered and mixed sets

Table 7 presents the means for all ordered and mixed sets conditions. As explained in the procedure section, the scores at all of the five levels of set complexity are provided by the same subjects in the ordered sets condition, whereas in the mixed sets condition, each mean score represents the responses of a different group of 20 subjects. Because of this, statistical comparison between ordered and mixed sets conditions is precluded.

Figure 4 graphically compares ordered and mixed sets results at each level of set complexity regardless of the type of

Table 7

Mean consistency scores of paired comparison preference responses by normal adult subjects for <u>ordered</u> and <u>mixed</u> sets of four stimulus types at five levels of set complexity.

	Number of Stimuli in Sets				
	3	4	5	6	7
statements	.9000	.8182	.8400	.8386	.7945
named colors	.8217	.8413	.8139	.7765	.7717
unnamed colors	.7650	.7875	.7695	.6895	.6850
tones	.7826	.7630	.6639	.5830	.5909
means of ordered sets column means	.8173	.8025	.7718	.7219	.7105
statements	.7650	.7650	.7890	.7280	.7080
named colors	.8100	.8550	.7110	.6855	.6665
unnamed colors	.8100	.7650	.7050	.6600	.6385
tones	.7200	.7650	.7035	.5140	.5935
means of mixed sets column means	.7763	.7875	.7271	.6469	.6516

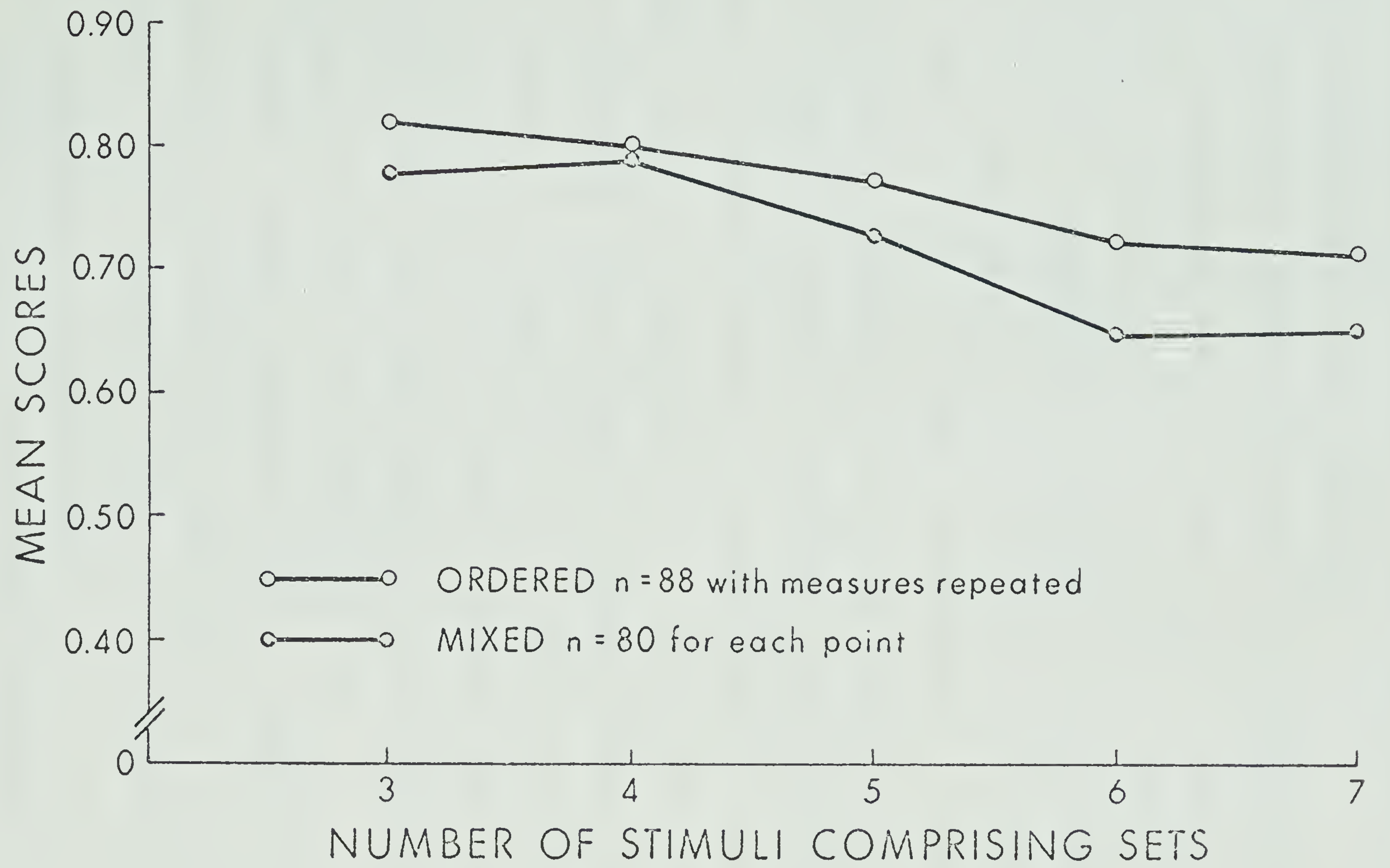

Figure 4: Mean consistency scores of paired comparision preference responses by normal adult subjects for ordered and mixed sets plotted against level of set complexity. Scores represent means of four different stimulus-type group means for ordered and for mixed sets conditions.

stimulus comprising the sets. These scores were arrived at by obtaining the means of the ordered and mixed sets column means shown in Table 7. Ordered sets scores are higher than those of mixed sets, and there is, in both cases, the trend toward lower scores for more complex sets.

This trend is somewhat more clear in the ordered sets data. The mixed sets results for sets of four stimuli is higher than might be expected. It is, in fact, virtually the same as that of ordered sets at that level of set complexity. Also in the mixed sets, the scores for level seven are higher than those for level six, though only negligibly. Nevertheless, it seems that the addition of the seventh stimulus to the sets did not effect a decrement in consistency scores for mixed sets. Figure 3 indicates that this is to be attributed to the particularly low score of tones at the level of six stimuli and the, not surprisingly, higher scores for tones at the next level. Had the data for six tones been more in keeping with the results for the other stimulus types at the sixth level, Figure 4 would have shown level seven somewhat lower than level six for mixed sets, consistent with ordered sets data.

Figure 5 compares ordered and mixed set results for each stimulus type. The results for named colors are especially consistent with expectations except for the somewhat high score for the mixed set at the fourth level.

Results for the other stimulus types are similarly in line with the predictions of the research. Two general observations

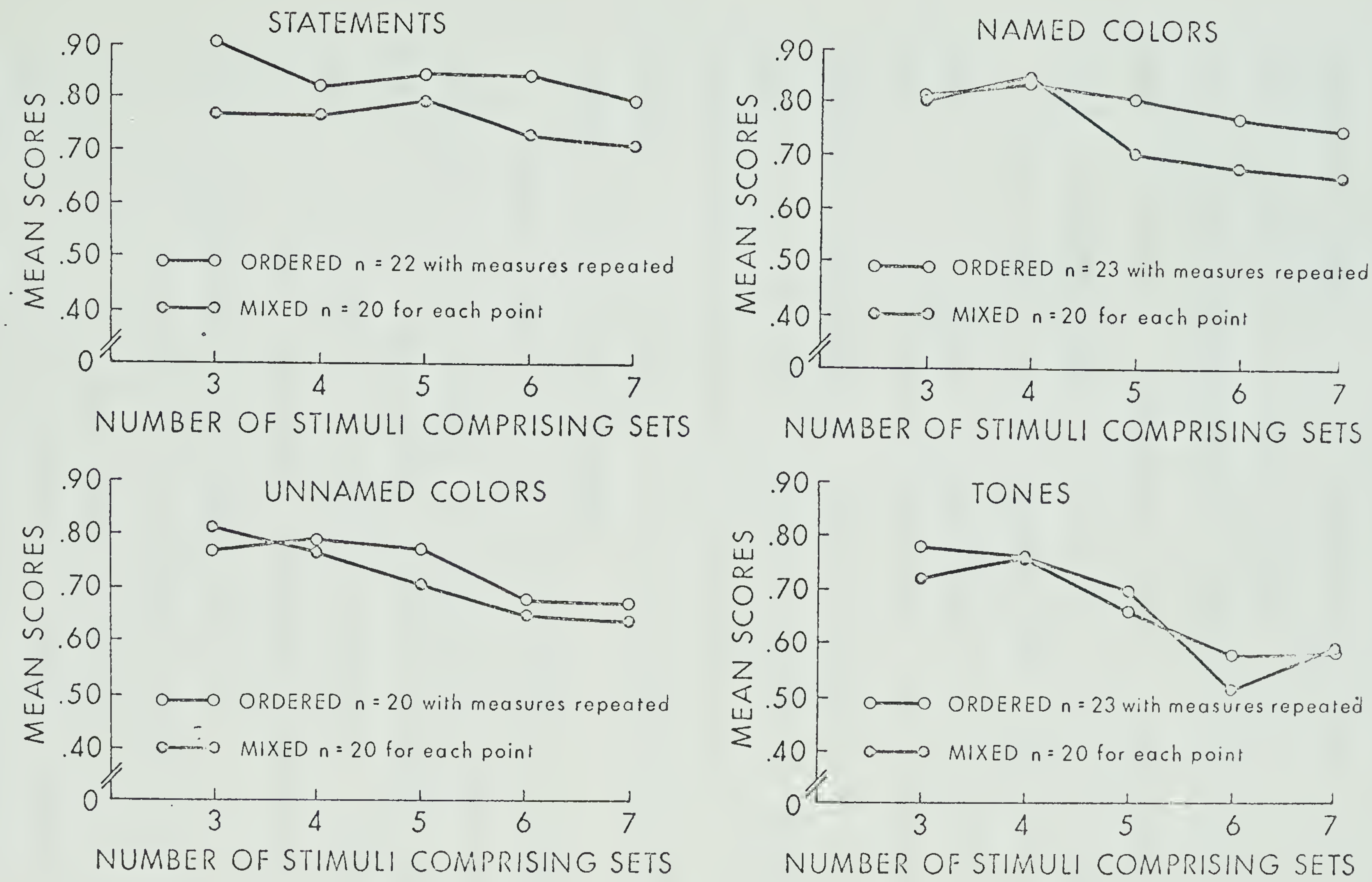

Figure 5: Mean consistency scores for paired comparison preference responses by normal adult subjects for ordered and mixed sets of four stimulus types plotted against level of set complexity making separate comparisons between ordered and mixed sets results for each stimulus type.

can be made from the four graphs of Figure 5. First, the increase in level of set complexity seems to affect the scores comparably in ordered and mixed sets. Second, the difference between ordered and mixed sets data appears to decrease as there is less verbal content in the stimulus material. In other words, on the whole, ordered and mixed set data lines in Figure 5 are furthest apart in the case of statements, nearer for named colors, nearer still for unnamed colors, and overlap in the case of tones.

At the level of seven stimulus items, results are especially clear for both ordered and mixed sets. For this reason a closer examination will be made of these data. The differences between ordered and mixed sets with respect to applications of treatments to subjects (which precluded a statistical analysis of differences between these two sets of scores) applied to the question of level of set complexity. At any one level, level seven in this instance, the two are comparable.

A separate analysis of variance was made to determine the differences between ordered and mixed sets organizations of the full sets of seven stimuli for each of the four stimulus types. This analysis is summarized in Table 8. Analysis shows both main effects significant, indicating that scores obtained from an ordered and from a mixed presentation are different ($P < .05$), and that there is a difference between the scores for the four different stimulus types comprising sets ($P < .01$). The latter also occurred in the earlier analyses reported in Tables 3 and 5, though not at so high a level of significance.

Table 8

Summary of analysis of variance for effect of ordered and mixed arrangements of sets and of level of stimulus verbal content with seven stimulus items comprising sets. Measures are paired comparison preference responses by normal adult subjects.

Source	d.f.	M.S.	F	P
A	1	.1552	4.79	<.05 *
B	3	.2043	6.74	< .01 **
AxB Interaction	3	.0239	0.79	n.s.
Error	160	.0303		

A= order of sets

B= stimulus type

Table 8 indicates no significant interaction between main effects for this one ordered-mixed comparison. There was, therefore, in this case of seven stimuli comprising sets, no significant difference between the influence of stimulus type in ordered sets and its influence in mixed sets.

Figures 6 and 7 present bar graphs of the scores for all stimulus types at this seventh level. Figure 6 shows that, within ordered sets, the progression from maximum verbal content (statements) to minimum verbal content (tones) had the effect of progressively diminishing the proportions of complete transitivity. This difference is present but negligible moving from statements to named colors, considerable moving to unnamed colors and well marked moving to tones where, though no score has a frequency greater than that of .90, it is reduced to bimodal standing. In every other case .90 is the strongly modal score.

In addition to reducing the proportion of perfectly consistent subjects, the lessening in verbal content also tends to spread scores more and more evenly over the range of possible scores. Though at the .90 end of the distributions, the statements and named colors' distributions are not very different, more scores are lower in the case of named colors, still more for unnamed colors, and so to tones where the distribution has become rather flat.

There are marked differences between the shapes of these ordered sets distributions and their corresponding mixed sets members shown in Figure 7. Whereas with ordered sets the attenuation

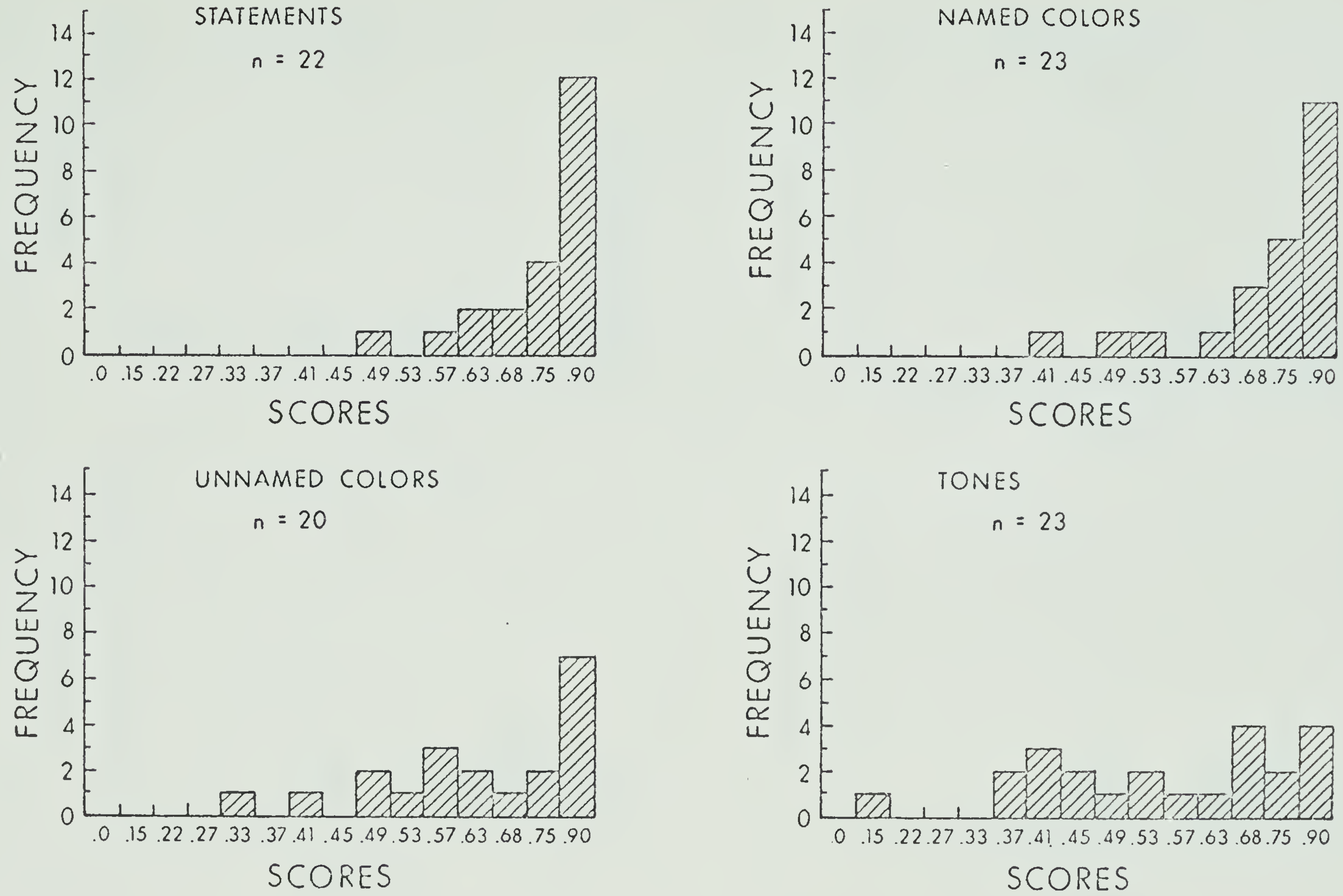

Figure 6: Distributions of consistency scores of paired comparison preference responses by normal adult subjects for ordered sets of four different stimulus types with sets composed of seven stimulus items.

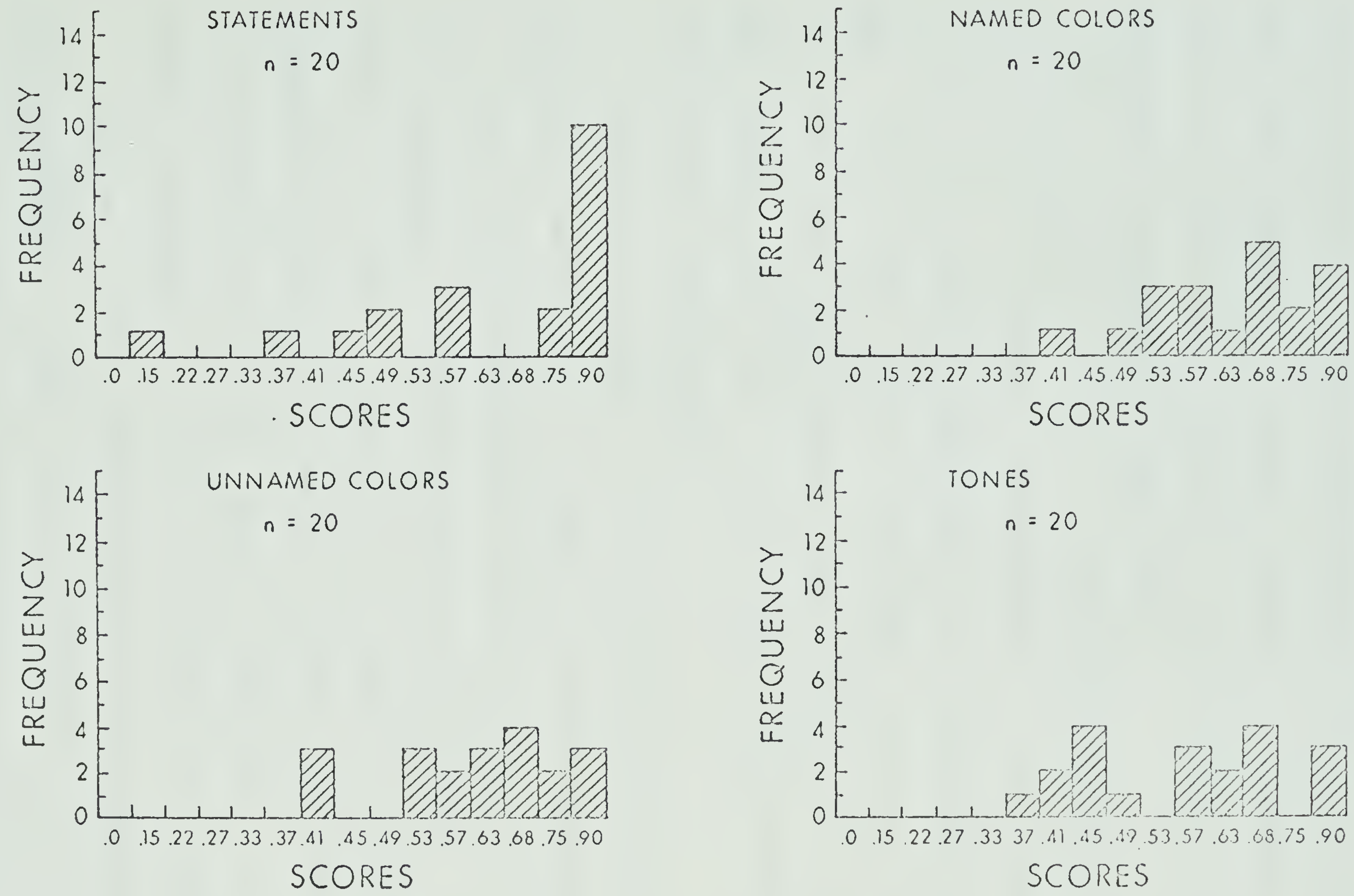

Figure 7: Distributions of consistency scores of paired comparison preference responses by normal adult subjects for mixed sets of four different stimulus types with sets composed of seven stimulus items.

of the modal prominance of the .90 score is accomplished gradually moving from statements to tones, in mixed sets .90 is not the modal value in any but the statements set. Nor is there a marked progression toward more dispersed scores in mixed sets moving from statements to tones. The range of statements scores is actually wider than that of any other set even without considering its peculiarly lowest score.

The scores for statements in mixed sets are just as spread over the range. Strangely, though there is a lower proportion of very high scores for mixed sets than for ordered sets, mixed sets scores do not, except for statements, spread any lower. In fact in the case of both unnamed colors and tones, one ordered sets subject scored lower than the lowest scoring member of the corresponding mixed set group.

Performance decrement: Table 9 presents the frequency distribution of responses to an ordered set of five statements A - E, the responses being made immediately after a set of four other statements had been disposed of by the subjects. These measures were taken to determine if an element of performance decrement attributable to extended responding occurs which could be responsible for the lower scores of larger sets. In this research, the length of a set is a coincident of its complexity.

The mean for this groups' responses to the ordered set of five statements is .8242. The distribution for the regular experimental ordered set of five statements, to which this test group is compared, is presented in Table 4, the mean being .8400.

Table 9

Performance decrement condition: Distribution of consistency scores of paired comparison preference responses by normal adult subjects for the ordered set of five verbal statement stimuli following presentation of an ordered set of four other statements.

Consistency Scores	Frequency
.90	15
.63	3
.51	0
.39	0
.27	1
.00	0
	n=19

An analysis of variance, summarized in Table 10 revealed no significant difference between these two sets of scores. Therefore, no conclusion may be made that lower scores for more complex sets is attributable to the greater exertion involved in making more responses.

Comparison of two differently constructed sets of three statements: Table 11 shows the distributions of scores for the two differently structured sets of the same three statements. Only two scores, representing either complete consistency or its absence, are possible for a set composed of only three items. A two-tailed Chi-Square test was applied to the data. Though the difference between the two sets of scores failed to reach the customary level of significance ($.10>p>.05$) it remains an open question whether stimulus sequence structure might influence consistency of response. This issue will be discussed later.

Color naming data: All subjects taking part in an experimental condition involving colors were asked, after all other responses had been obtained from then, to write the name of all fourteen color test stimuli as they were presented one at a time. From these lists, measures were taken of the number of different names the total 150 subjects tested used in reference to each color, the name of most frequent occurrence for each color and the percentage of the subjects responding with this model name. This information is provided in Table 12 for both named and unnamed colors. It should be noted that the modal name

Table 10

Summary of analysis of variance for effects of performance decrement due to extended responding. Measures are consistency scores of paired comparison preferences responses by normal adult subjects to ordered sets of five statements of activity.

Source	d.f.	M.S.	F	P
Presentation	1	.0025	0.113	n.s.
Error	39	.0225		

Table 11

Frequency distribution of consistency scores of paired comparison preference responses by normal adult subjects for two differently structured sets of three verbal statement stimuli. The two sets are designed to provide antecedent-consequent and consequent-antecedent structures.

Consistency Scores	Frequency	
	Ordered Set	Mixed Set
	AB, AC, BC	BC, AC, AB
.90	25	30
.00	5	0
	n= 30	n= 30

Table 12

Data on names provided by 150 normal adult subjects for Munsell color surfaces which are well and unwell named in the English language, showing the name most often given by the subjects for each color, percent of subjects giving that modal name and the total number of names used by all subjects for each color.

Named Colors	Munsell Specification	Modal Name	% of Ss Responding With the Modal Name	Number of Names used by Ss
A	2.5 YR 6/16	orange	59	21
B	5 Y 8/14	yellow	62	13
C	2.5 G 5/12	green	48	34
D	7.5 YR 3/2	brown	72	17
E	5 R 5/14	pink	14	43
F	5 PB 5/12	blue	42	30
G	5 P Max (3.8/11)	purple	49	39
Unnamed Colors				
A	7.5 BG 5/8	turquoise	28	47
B	5 G 6/10	light green	35	35
C	7.5 Y 7/12	yellow	64	20
D	2.5 BG 5/10	green	22	43
E	5 B Max(5.3/8.8)	blue	48	24
F	5 RP 5/12	pink	32	55
G	10 P 5/12	purple	13	56

of named color E, intended as well named red, is actually pink.

No statistical tests were applied to these data. However, it seems clear that generally a greater proportion of subjects tended to offer the modal names when responding to named colors and that unnamed colors elicited considerably more names. Nevertheless, scores for the two types of stimuli do overlap in some instances. This indicates that our groups of color stimuli were not as discrete as had been hoped.

Discussion

In the introduction, the methods and limitations of traditional approaches to transitivity were dealt with. A description was made of conditions of stimulus structure which could promote the appearance of intransitivities,but without recourse to probabilistic notions of response.

Several experiments were conducted which manipulated stimulus verbal content and complexity of stimulus combination to test transitivity of preference responding using the method of paired comparisons. The results satisfied the hypotheses indicating that consistency of preference response is influenced by the verbal coding of stimuli and by the structure in which stimuli appear.

Under almost all experimental conditions, most subjects offer transitive sets of responses. It is only some fraction of the sample that provided any intransitive responses under these treatments. This was also the case under the conditions of Tversky's studies (1969), where transitive subjects were screened out prior to experimentation.

It appears from the results that transitivity is a model of choice which accomodates behavior very inexactly. This of course accounts partially for the use of stochastic principles in reference to cognitive and judgmental models. Nevertheless transitivity continues to hold a very prominent position in decision theory, as is indicated by Tversky's comment that transitivity 'is one of the basic and most compelling principles of

rational behavior'. (Tversky, 1969)

Just how creditable is the concept of the 'rational man'? The results reported here suggest a questionable status for this hypothesized man. There was as much response immediacy when subjects offered responses for unnamed as for named colors; and they appeared to have no more difficulty in arriving at decisions in these cases. Yet the two sets of responses demonstrate a different substructure of rationality, if consistency is to be taken to characterize rational behavior.

To discount the appearance of subject inconsistency on the basis of randomness of response seems to neglect the possibility to account for the behavior more precisely. It cannot be concluded that these subjects made mistakes. There were no tasks stated for them of the sort that criteria of correctness would apply. A demonstration that subjects are consistent in individual choices but inconsistent in sets of responses (e.g., consistent in their inconsistency) would argue in favor of finding some non-transitive model to account for patterns of behavior. This demonstration of consistency within inconsistent sets of response is what stochastic transitivity accomplishes. And a step toward the specification of non-transitive models of choice is made by Tversky (1969). However, his lexicographic model for multidimensional preferences and the additive model are difficult to apply to our data.

The conclusions reached earlier may not explain Tversky's findings; however, they do indicate where classically rational

models of preference are unsatisfactory and suggest specific questions for further research. For example, if the general hypothesis that rationality is an invented cognitive organization is true, then the non-task preferences of children should demonstrate characteristically intransitive relations. If inconsistent response patterns are reproductible (reliable), we should have evidence suggesting the desirability of non-commutative models for cognitive activity. However, rather than attempt to exploit such a difficult theoretical strategy at this point, it appears more profitable first to study more intensively the simplest choice sets (those composed of three stimulus items). But against this it should be clear that the differences attributable to stimulus types (i.e., verbal content) reported in this study are considerably more pronounced in larger sets. This is shown in Figures 8 and 9. Here it appears very clearly that the breakdown of rationality is more obvious at these higher levels of set complexity. Also the distinction in consistency of response between the different stimulus types used in this study shows itself more evenly in the larger sets.

The syllogistic form of transitivity statements

Transitivity is a particular relational arrangement of triples. Analysis of transitivity of sets of more than three elements simply regards them as interlocking complexes of threes. In this study, taking the simplest set, A, B, C, the elements are related in three steps: the first step relates the first element with a middle one; the second step relates the third element with the

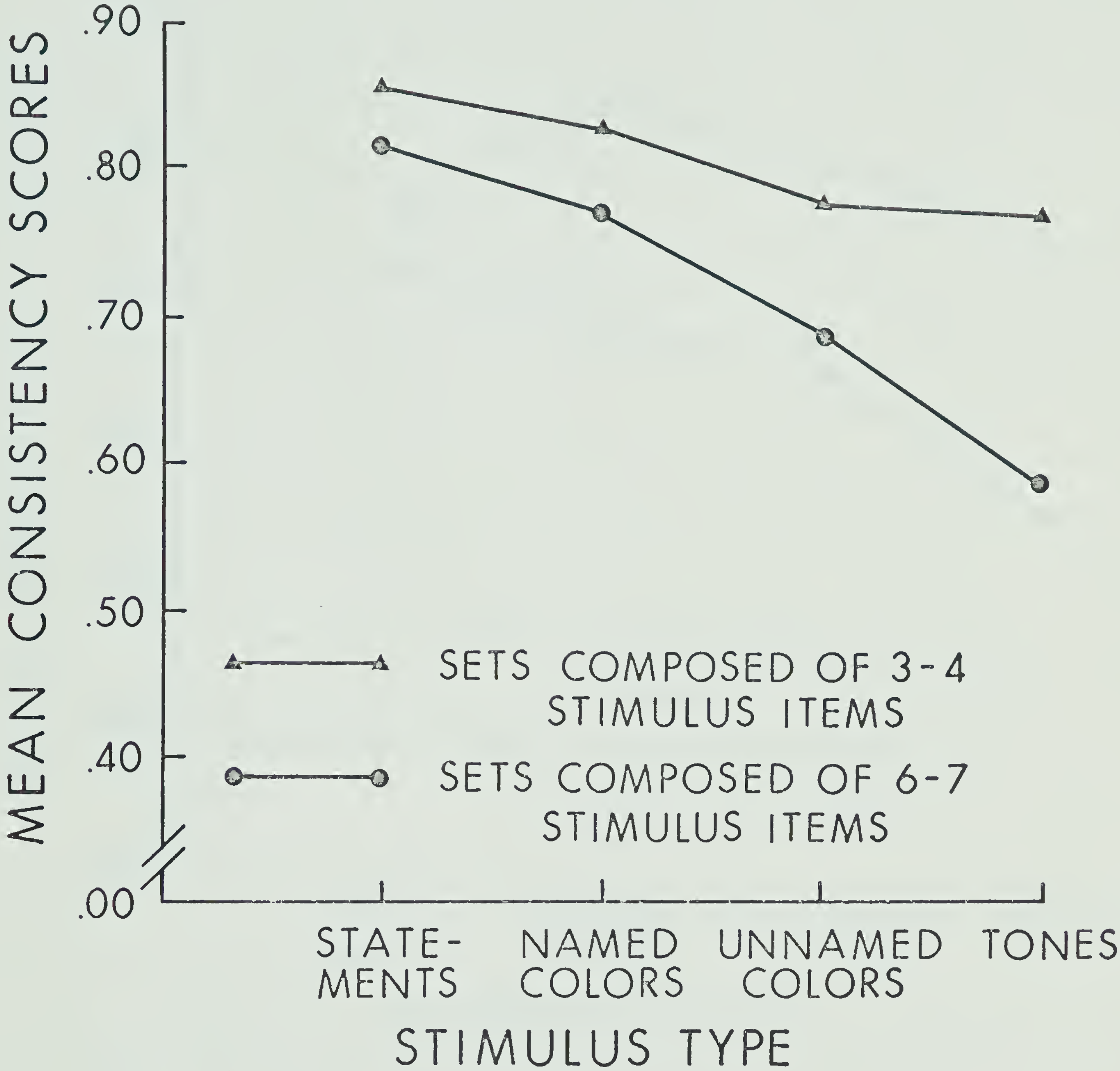

Figure 8: Mean consistency scores of paired comparison preference responses by normal adult subjects for ordered sets of low and high complexity plotted against level of stimulus verbal content.

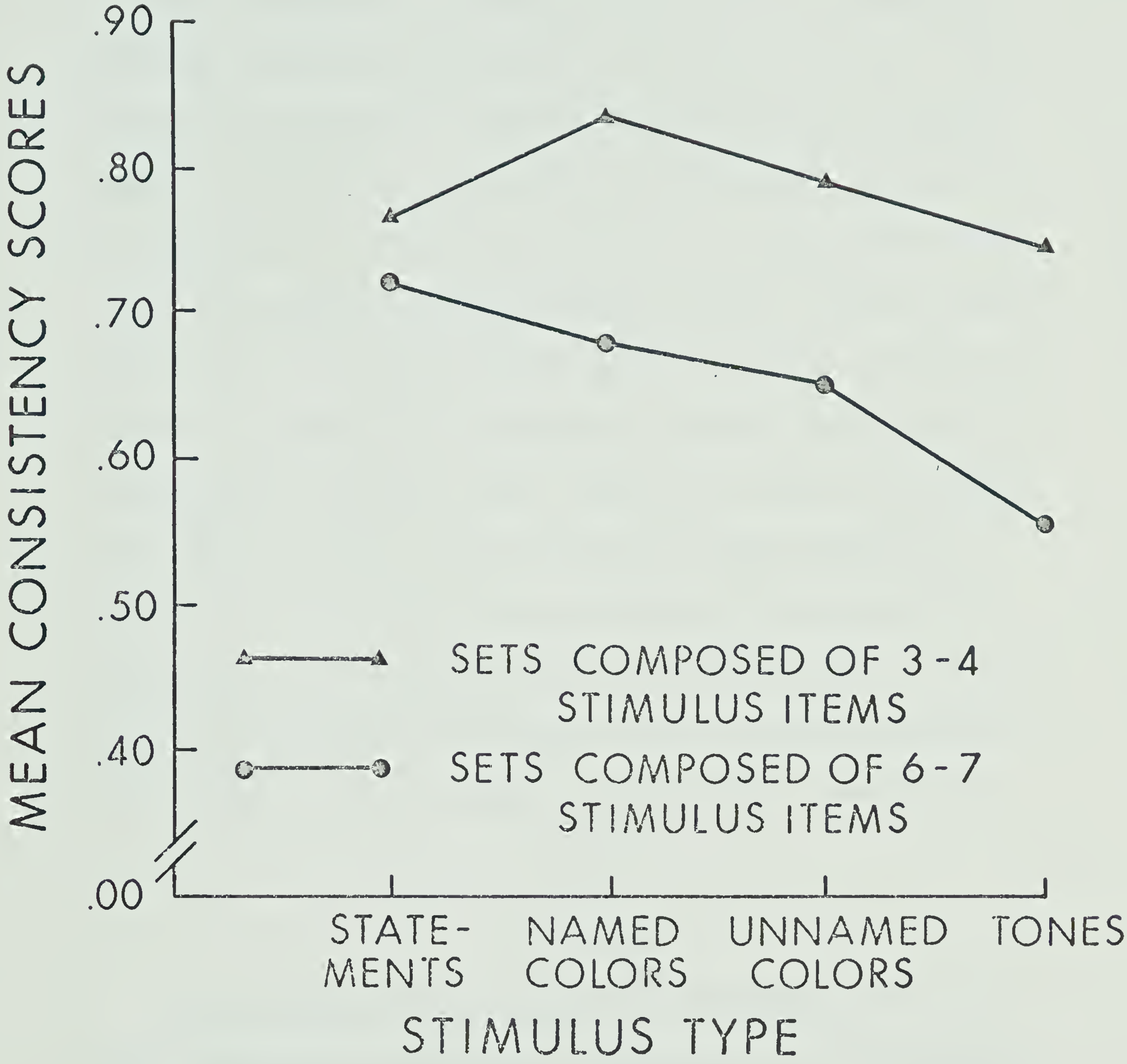

Figure 9: Mean consistency scores of paired comparison preference responses by normal adult subjects for mixed sets of low and high complexity plotted against level of stimulus verbal content.

middle one; and the final step drops the middle term and relates the other two, which have not before confronted one another except by implication.

This structure is analogous to the form of syllogistic reasoning described by Woodworth and Schlosberg (1964). These authors report research revealing that the form of the appearance of the premises is a critical psychological factor in the acceptance of invalid conclusions in the syllogism's final step. For example, syllogistic forms such as, 'Linda is darker than Phyllis but lighter than Alice; Who is lighter Phyllis or Alice?' were found to be considerably more difficult than the same relations presented thus: 'Phyllis is lighter than Linda and Linda is lighter than Alice; who is lighter Phyllis or Alice?' The structural difference between the two form involves the order of presentation of individual items. For purposes of transitivity, the premises and concluding problem of this lightness contest between the three girls appears thus:

$$L < P$$
$$L > A$$
$$P \; ? \; A$$

One syllogistic form appears to aid rationality of response, while the other appears to hinder it. The transitivity results of this study were supportive of these syllogistic phenomena.

An auxiliary experiment tested the difference in transitivity obtained by the experimental ordered set (AB, AC, BC) and

a mixed set (BC,AC,AB). The two sets provided a reversal of structure. Both sets were run with verbal statement stimuli. Though ordered set received more intransitive responses than did mixed set the difference did not reach significance. Of note is the perfectly transitive responses of the 22 subjects in the experimental ordered set statement group, which of course received the same set of statements as the 30 ordered set subjects in this auxiliary study.

The ordered set condition provides considerably more stable results in sets composed of larger numbers of stimuli than in sets of three or four items (refer to Figure 2). Results are clear that, contrary to its predicted effect, an ordered set of three items can hinder transitive treatment of choices. This result can be attributed to the structural similarity of the ordered set to the more difficult of the syllogistic forms reported by Woodworth and Schlosberg (1964). Note the structural similarity of:

$$\begin{array}{lcl} L < P & & A \lessdot B \\ L > A & \text{to} & A \gtrdot C \\ P \; ? \; A & & B \; ? \; C \end{array}$$

The conditions present in this form which make it conducive to intransitive responses are: 1. That it is only in the third step of the logical progression that an intransitivity can occur, which is one of the defining qualities of the syllogistic form; 2. That the same items (e.g., Linda for the syllogism and A for the transitivity problem) appears first in the two premises

of the syllogism and in the first two of the preference pairs, which, for the syllogism, is true also of the easier problem; 3. That there is a reversal in the second pair of the order of choice in the first. It is this last condition that seems to produce difficulty in both cases.

Only a few of the possible premises dispose a person to error. For the syllogism if, instead of the form listed above, the premises were $L > P$, $L > A$, there is insufficient information to determine the relationship between P and A. However, error is possible. In fact, either $P > A$ or $P < A$ is in error.

For transitivity of preferences, the situation is just the opposite; for if A·> B and A·> C, there is no possibility of an intransitive response in the final choice. Either B·> C or B<· C will be transitive. For intransitivity to occur in choices for the <u>ordered set</u> under discussion, it is, therefore, a necessary but not sufficient condition that the person reverse his direction of choice in the first two pairs, e.g., either A<· B then A·> C or A·> B then A<· C. And it is specifically the proximity of these two reversed pairs in the set that produces confusion in syllogistic problems and intransitivity in preferences.

This could account for the tendency for the scores of the <u>ordered sets</u> composed of three stimuli to be somewhat lower than might be expected from the apparent simplicity of the set's structure. At no point beyond the smallest set (i.e., three stimuli) do two successive pairs begin with the same item. In <u>mixed sets</u>, on the other hand, this proximity can occur at any level of set complexity.

Summary

The transitivity model has been applied to preference response by various researchers, notably Coombs (1958) and Tversky (1969). Generally this has been done with *stochastic transitivity*, a form of the model founded on the contention that choice behavior is largely random. The research reported here demonstrated intransitivities of preference without recourse to probabilistic notions of response. The internal consistency of response was studied in a variety of ways varying both the verbal content of stimulus material and the structure of presentation of the stimuli.

Hypotheses followed color stimulus demonstrations of the dependence of cognitive structure on language (Brown and Lenneberg, 1954; Lenneberg and Roberts, 1956). It was predicted that transitivity of preference for sets of stimuli would vary with the *codability* of the stimuli in language. Color stimuli of high and low verbal content were selected on the basis of Chapanis's (1965) work in color naming. Verbal statements of activities adapted from the *Kuder Personal Preference Inventory* and musical chords were selected as having maximum and minimum verbal content. The prediction was that transitivity of response would decrease ordinally as verbal codability of stimuli decreased.

Using normal adult subjects, measures were taken for each of four stimulus types with sets of choices made up of all paired

combinations of three, four, five, six and seven stimulus items. (i.e., at five levels of set complexity). It was predicted that transitivity of response would decrease as complexity of sets increased.

The sequence for presentation of pairs were organized both with a repetitive pattern (i.e., ordered sets) and randomly (i.e., mixed sets). The prediction in this case was that an ordered succession of preference material would facilitate transitivity.

All hypotheses were supported by results. Results were discussed in relation to the dependence of rational performance on structure of stimulus presentation.

A skepticism was expressed for the application of consistency models of behavior to man and for the characterization of man along the lines of classical rationality.

References

Abelson, R.P. (1964) The choice of choice theories. In Messick, S. and Brayfield, A.H. (eds.) Decision and choice, New York: McGraw-Hill.

Audley, R.J. (1960) A stochastic model for individual choice behavior. Psychol. Rev., 67, 1-15.

Block, H.D. and Marschak, J. (1960) Random orderings and stochastic theories of response. In Olkin et al. (eds.) Contributions to Probability and Statistics. Stanford, Calif.: Stanford.

Brown, R.W. and Lenneberg, E.H. (1954) A study in language and cognition. J. Ab. Soc. Psychol., 49, 454-462.

Chapanis, A. (1965) Color names for color space. American Scientist, 53, 327-346.

Coombs, C.H. (1958) On the use of inconsistency of preferences in psychological measurement. J. exp. Psychol., 55, 1-7.

Corwin, T.R. and Boynton, R.M. (1968) Transitivity of visual judgments of simultaneity. J. exp. Psychol., 78, 560-568.

Estes, W.K. (1961) A descriptive approach to the dynamics of choice behavior. Behav. Sci., 6, 177-184.

Garvill, J. and Molander, B. (1968) Asymmetric effects in cross-modal transfer. Umeå Psychological Reports, No. 3.

Griswald, Betty J., and Luce, R.D. (1962) Choices among uncertain outcomes: A test of a decomposition of two assumptions of transitivity. Amer. J. Psychol., 75, 35-44.

Hammond, K.R. (1964) Toward a recovery of rational man. Colorado Quarterly, fall, 101-120.

Harary, F., Norman, R.Z. and Cartwright, D. (1965) Structural Models: An Introduction to the Theory of Directed Graphs. New York: John Wiley & Sons.

Kendall, M. G. and Smith, B.B. (1940) On the method of paired comparisons. Biometrika, 31, 324-345.

Kendall, M.G. (1962) Rank Correlation Methods. New York: Hafner.

Langer, J. and Rosenberg, B.G. (1966) Symbolic meaning and color naming. J. pers. soc. Psychol., 4, 364-373.

Lenneberg, E.H. and Roberts, J.M. (1956) The language of experience. Memoirs of the International Journal of American Linguistics, 22, No. 13.

Lenneberg, E.H. (1957) A probabilistic approach to language learning. Behav. Sci., 2, 1-13.

Lenneberg, E.H. (1961) Color naming, color recognition, color discrimination: a re-appraisal. Percept. mot. Skills, 12, 375-382.

May, K. O. (1954) Intransitivity, utility, and the aggregation of preference patterns. Econometrica, 22, 1-13.

McGuire, W.G. (1966) The current status of cognitive consistency theories. In Feldman, S. (ed.) Cognitive consistency: Motivational Antecedents and Behavioral Consequences, New York: Academic Press.

Munsell, A.H. (1929) Munsell Book of Color. Munsell Color Company, Baltimore.

Ochs, S. and Booker, H. (1961) Spatial and temporal interaction of direct cortical responses. Experimental Neurology, 4, 70-82.

Restle, F. (1961) Psychology of Judgment and Choice. New York: Wiley and Sons.

Thurstone, L.L. (1945) The prediction of choice. Psychometrika, 10, 237-253.

Tversky, A. (1969) Intransitivity of preferences. Psychol. Rev., 76, 31-48.

Washburn, M.F., Haight, D. and Regensburg, J. (1921) The relation of the pleasantness of color combinations to that of the colors seen singly. Amer. J. Psychol. 32, 145-146.

Winer, B.J. (1962) Statistical Principles in Experimental Design. New York: McGraw-Hill.

Woodworth, R.S. and Schlosberg, H. (1964) Experimental Psychology, revised edition. New York: Holt, Rinehart and Winston.